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Benefits of Using Information and Communication Technologies (ICT) for Teaching and Learning in K-12/13 Classrooms

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Introduction

The SchoolNet Initiative has made us aware of the electronic network potential for moving Canada into a knowledge-based economy and of the opportunity of applying high-speed multi-media networks for learning purposes at the K-12/13 levels. The SchoolNet National Advisory Board is now considering the next strategic steps to be taken to meet the challenge by asking: *Can the investment in hardware, courseware and professional development for teachers allow us to achieve a "superior form of learning" for Canadians in a knowledge society?* Because of the promising pedagogical and economic impact already evidenced by the use of modern learning technologies in schools, it seems that Canada, in the family of advanced nations, would wish to embrace initiatives that will lead to improved teaching and learning.

The early stages of ICT integration in K-12/13 schools and classrooms are such that, on the one hand, it will take many years to properly assess pedagogical benefits. On the other hand, there is no evidence to justify putting an end to continuous investment in ICT. Past experience has shown that well demonstrated positive results applicable to large numbers of students are a rarity in education. Today, however, an increasing number of researchers, including cognitive scientists and teacher educators, recognize that the teaching-learning process must evolve. It is advocated that teacher-talk and rote knowledge (addition and retention of facts, principles, and procedures) on the part of the learner must give way to teaching for understanding (Bereiter, 1998), life-long learning and higher-thinking skills acquisition for all.

Corporate leaders are now among the advocates of these new teaching skills. Business and industrial firms sense that the new culture of work (openness, collaboration, innovation, people judged on contribution, new authorities, trustworthiness and trust[1]) calls for a change in the way we conceive of learning, thus on the way of delivering instruction. The traditional approach to teaching requires that classroom learners be silent most of the time, and act in conformistic and obedient manner – the "assembly-line" worker is the guiding metaphor here. The constructivist approach[2] to learning is more in accordance with what is now expected of the knowledge worker (information retrieval, complex problem-solving, higher-thinking, communication, and collaboration skills). The task-at-hand being the preparation of all students to be lifelong learners, and socially responsible productive citizens, a new vision of learning, indeed, is necessary (see SchoolNet's document: the Vision of learners in the 21st century). This paper will now explore the linkages between advanced technology and advanced pedagogy, and set the foundations of a strategy to maximize each in order to enhance student learning and performance.

1. Canada's learning project as a knowledge society

According to Bates (1998), in the XXIst Century, learners will need to access, combine, create and transmit audio, video, text, and data. Will our society be in a position to prepare K-12/13 learners – and in sufficient number – to cope with the requirements of knowledge work so different from the conformistic assembly-line worker mentality? That is a critical issue which will have to be addressed by the Canadian education systems. As long as computers remain in computer "labs", they are removed from the rest of the curriculum, and the life of the classroom; but when the computers make their appearance into the classroom, both the teacher and learners are then faced with new challenges and opportunities as they are called upon not simply to learn but to learn with computers[3].

Our collective capacity to reconceptualize learning and teaching is now at stake. Reconceptualization calls for a "re-vitalization" of the teacher's role (the assembly-line model) away from the technology available in the fifties and sixties to meet the educational demand: fifty-minute classes, 180 students a day, teacher isolation, and college-admission decisions driven by test scores and course requirements. That model is unfortunately still the way of life for a great number of teachers who view the systematic delivery of information (their *techne*) as their primary role.

Information and communication technologies (ICT) present us with a unique opportunity and challenge, to reach for a more human approach to teaching and learning with the purpose of preparing knowledgeable, democratic and socially responsible citizens. Therefore, to downplay the role of the teacher in the education of the knowledge worker of tomorrow – the formation and cultivation of understanding (*episteme,* knowing-that) and practical judgment (*phronesis,* knowing-why) – and to

overplay that of the skillful production of artefacts as well as that of the expert mastery of objectified tasks (*techne*, knowing-how), would be here ill-advised. This new pedagogy constitutes not only a model of improved human relations but of sociocognitive processes in the classroom.

However, it is important to be aware of the nature of the likely impacts of changing the rhetoric (or vision) of what learning is all about. It is an undertaking of major importance and coherence will be a transcending issue: For instance, an education system may voice the importance of critical thinking or problem solving in a new way, but rely on rote knowledge when it comes to evaluating student learning. Relevant processes need to be identified, and will require time to be developed and disseminated. That is to say that ICT may be in place, but if the old discrete instructional prescriptions still prevail, then no significant change is likely to occur.

These are serious matters that will affect our future in Canada[4]. External forces and globewide competition not only suggest the need for an in-depth analysis, but equally, an aggressive and strategic action plan.

2. What is meant by ICT integration and its benefits?

Depending on whether the orientation of a community is to use teacher-proof courseware from the Net or to *re-place* the teacher in a role that is less mechanistic than the assembly-line model, the benefits are going to be quite different; and therefore, practical wisdom calls for a balanced approach. Too much emphasis on the former orientation is hardly warranted. To rely only on the latter however, is rather naïve when one considers that most classrooms are still run in a traditional way. True enough, any change requires knowledge, pressure and support[5]; but here, in addition, one must keep in mind that the teacher professional development in using ICT as a pedagogical tool, is equally of crucial importance.

This situation in education compares favorably with the one prevailing in the medical field at the beginning of the XXth Century. Research and technology did change the practice of medicine and ensuing benefits have been enormous; a similar challenge is facing the field of education. As technology improves and unfolds in the context of classroom life, the teacher must identify with the learners the proper inquiry questions, or Internet resources. The structure of a learning activity, the way it is embodied into the student's experience, is more important than the features of the technology itself[6]. The outcome, unanticipated by many concerned with ICT and education, lies in the fact that with the advanced technology, the teacher is called to act pedagogically, not technically.

Here, however, one must be aware that different psychological foundations (theories) represent different beliefs about how individuals think and learn. Looking at what research requires in order to generate a reliability dimension of the teacher's pedagogical decisions, one finds that theories and models linking learning, teaching and technology are based on competing research findings. The reconciliation between these different perspectives is a difficult task, but given the recent advances in cognitive science[7], the identification of underlying similarities and mismatches between goals and means, is actually less difficult today than it was ten years ago (e.g., the evidence underlines the key role of the teacher as a learner, guide, and inquirer in the networked classroom, and in a networked society).

Canadian exemplary uses of ICT in teaching and learning

The breadth and quality of innovative use of ICT for learning purposes in K-12/13 classrooms is illustrated here by the following cases :

- **Interactive Computer-Based Laboratories in Science, Technology and Mathematics.** A number of Newfoundland and Labrador high schools experimented with virtual classes with an aim to manage isolation (e.g., http://www.k12.nf.ca/clarenville-high). The Vista School District Digital Intranet represents two dimensions of change : on the one hand, curriculum and technology and, on the other hand, the re-organization of classes within an Intranet. Early research results point to the transition from closed to open teaching and learning environments (Piper, Power, & Stevens,

1998). A related case is that of ITP Nelson Canada/The Learning Equation, in partnership with the Canadian Western Provinces who have jointly developed computer-based math resources (TLE). Though the interactive materials are not on-line but on CD-ROMS, they announce the kinds of visual displays and simulations and other advanced interactive learner-centered activities that will increasingly be put on-line. The student engages in hands-on learning, and interactive learner-centered activities (e.g., direct screen manipulation, that is, dynamic geometry). The results of the evaluation conducted by Psychometrics Canada Ltd, indicate a positive effect on student learning. Further research is likely to be most revealing as to long-term effects, and which factors explain significant differences between TLE and NON-TLE classrooms in some schools and in some schools not.[8]

- **The Writers In Electronic Residence Case: Linking with community members.** WIER uses a network conferencing system (FirstClass) to link writing and language arts students to Canadian authors, teachers, and to each other for the exchange and discussion of original work. WIER involves the participation of up to 120 classes in any given year from all areas of the country and including students ranging from the junior elementary to the senior high school levels. Writing fluency improves, as organization and mechanics of text (Owston and Wideman). Teachers found the opportunity to raise questions and issues with more experienced peers and WIER staff in the on-line staff forum met nearly all of their support needs beyond localized technical issues (http://www.edu.yorku.ca/csce/tech98-3.pdf). A larger initiative as regards Web-based writing is SchoolNet News Network. Under STEM-NET's leadership and coordination, it has become a national service for students and by students. Networked students engage in multimedia journalism (http://www.stemnet.nf.ca/snn). Both initiatives are models of what can be achieved on-line in the critical area of writing.

- **The CSILE Case: On-line collaboration for understanding purposes.** The OISE/UT-based research team has conducted many studies that show the benefits of the socio-constructivist approach for deep learning. A shift away from one-to-one and one-to-many communication patterns occurs for learners engaging in computer-supported collaborative learning; elementary school learners are found to contribute in advanced ways to the classroom discourse when using CSILE/Knowledge Forum software. Many-to-many communications can be managed in productive ways, making learners more responsible and active as they inquire into far more advanced topics than what is usually observed in elementary classrooms; several papers reporting on studies conducted in Canada may be accessed on CSILE website (http://csile.oise.utoronto.ca). This leading-edge Canadian technology and pedagogy is also being used and researched upon in the U.S., and in other countries.

- **The PROTIC Case: Providing high access and support.** In this school-within-a-school program, junior-high learners, each equipped with a networked laptop, engage in individual and collaborative learning projects about two-thirds of the classroom time throughout the school year. Technology skills are not taught in and of themselves, but in the context of curricular activities in which peer learning is highly noticeable. Learners are facing the challenges of learning and teaching from complex versus linear information access; their works become more visible to one another. The meanings, reconstructed situations, and learning results of using the networked computer on a daily basis are sorted out, and early results are positive. Their portfolios demonstrate advanced technology, inquiry, and meta-cognitive skills as well as deep understanding of a number of topics (http://protic.net).

In each case, evaluation studies or research projects were or are still in the process of being conducted. They contribute and build upon what is known as far as ICT benefits in learning are concerned.

Benefits of ICT in learning and teaching

Given the right conditions for access and use, significant gains in student learning are recorded with ICT. Above all, one must be aware that it is not the media alone that counts[9]. It is important that teachers

see a clear relation between the use of ICT and the learning curriculum[10]. Expected effects of ICT on learning are closely correlated with the teachers' and learners' abilities to use them. Learning *about* technology is to a certain extent, a prerequisite to learning *with* technology. Before a specific software is minimally mastered, teachers won't feel that they or their students save time using it. Maddux, Johnson, & Willis (1997) distinguished two types of computer uses in education: Type I applications are those in which technology is used to teach the same things as before, but here the tool makes it easier, quicker, and more efficient; Type II applications are new and provide better ways of teaching with the support of technology, and of other professional educators. As observed in Canada and elsewhere, socially distributed knowledge networks contribute to the emergence of a new paradigm, called interconnectedness[11]. As far as educational technology is concerned, one of the key advisors to the United States Federal Government points out that the interconnectedness brings in pedagogical benefits:

> Collaborative learning, constructive learning, and apprenticeships are not new concepts in learning. But they've never been sustainable. Teachers who try them usually burn out. Why? Because they didn't have an infrastructure that supported them. Technology can help establish a supportive infrastructure that makes it possible to use those powerful models without burning out. (Dede, in O'Neil, 1995).

After all, the education systems were designed earlier in this century using the learning theory and the technology available at the time. Because most of the teachers are still involved in the traditional way of teaching, they quite naturally feel that there is little classroom time for creative uses of the networked computer. Breaking away from the standard operating procedures, and developing new learning environments constitute in itself quite a mammouth task, and it is urgent that the teachers be made aware that ICT can clearly be, in this respect, of immense help.

ICT in schools and classrooms tend to attract school learners' interest and motivation[12]. The most extensive meta-analysis conducted on school learning (Wang, Haertel, & Walberg, 1993) pointed out that the positive relationship between the learner and the learning environment was the most critical factor. For those students who do have access to a networked computer at home, the classroom becomes more attractive when networked. For all the learners who do not have access to the network at home[13], the presence of computers in schools and classrooms helps to narrow the gap between those having and using computers at home and those who don't. Another gain as regards equity is that digital communications can engender the promotion of a more equitable participation among disadvantaged groups (Hsi & Hoadley, 1997).

4.1 Learners' expected benefits at an early stage of use of networked computers

When an adequate level of access and use is achieved, the specific early pedagogical benefits that may be expected out of the very first years of integrating ICT in schools and classrooms are as follows:

4.1.1 A look at the benefits to be expected at the content level:

- *Acquisition of computer and networking skills.* In the early stages of ICT integration, all those learning to use on-line resources and tools have to devote time to get acquainted with the system possibilities. The software design is a critical element in regards to how the tool can be used. Web-based applications (on the Internet or on an intranet) and activities have to be grasped; hands-on activities and classroom projects are designed for that very purpose. Activities will vary, according to how the computer is perceived, i.e. as a tutor per se or as a tool.

- *Availability of a larger spectrum of subjects/courses.* There must be application of the principle of equality of opportunity for equity at the content level (choice) as well as at the connectivity level (access). Networked computers can be particularly useful in rural and remote schools in accessing a growing range of learning resources and remote libraries and in getting the opportunity for students to participate in virtual learning experiences.

- *Increases in the learning of academic subject matters.* The question of whether ICT can help to boost learning has been resolved: In situations where appropriate-support conditions are provided to the teachers using ICT, increases in student learning are found[14]. Scaling these results up is

the real challenge: As innovative practices using ICT are more widely adopted, the support conditions tend to be reduced, and learning outcomes tend to be disappointing. To tie the innovation closely to a particular curriculum makes it easier for the teacher to weave this technology into instruction. The Learning Equation interactive courseware (TLE) mentioned above is such an attempt. The evaluation of TLE conducted in Grade 9 math classes shows quite encouraging learning results[15]. These results also suggest that innovation needs to occur simultaneously in curriculum, pedagogy, assessment, and school organization. The time and effort expended on modern learning technologies are then likely to produce more improvements in learning outcomes (Dede, 1997).

4.1.2 A look at the benefits to be expected at the processing level:

- *Involvement with exciting, engaging, and challenging technologies.* To engage learners in meaningful learning materials and activities and to keep them intellectually involved are the basic elements of any teaching effectiveness. In some instances, the networked computer is used as a tool to reproduce or produce (texts and images), and to support individual, group, and classroom inquiries and projects. In three of the largest initiatives conducted in the U.S.[16], most of the students use the Internet for individual work (40-60%). Project teamwork and recreation come second (25-50%), ahead of whole-class use (8-18%). In other instances, the networked computer (and as access and content increase) may be called upon to help the teacher by presenting more visual learning activities which are likely to be responsive to the rate of learning absorption of the individual learner. Given proper engagement from the part of the learner, reduced learning retention time (34% less, Kulik, 1994) has been recorded, but the difficulty of transferring such learning to real-life situations has also been observed (in the case of maths, for instance, see Kieren, 1998).

- *More convenience engendered.* Anytime-anywhere access to information and to others for communication and collaboration purposes bring flexibility while enriching educational resources. It could provide continuity of learning to a student when he or she cannot physically access school.

- *A broader range of learning activities.* In the short run the use of the Web is likely to remain at the first levels of interaction with on-line information (looking at different sites and their features, searching for information and organizing it). Among the teachers having their students use the Internet in complex ways, 7% of all teachers had students e-mail at least 3 times during the 1997-1998 school year, and 4% had students "become expert about a topic and publish text and pictures on the Web" (Becker et al., 1998). In the three large-effort initiatives conducted in the U.S. and referred to above, one teacher out of ten engaged students in the creation of Web pages as a service to others.

4.2 Teachers' perceived benefits (at an intermediate stage of use: 3-5 years)

Knowing that about 5% of all teachers are currently having their students use the Internet for inquiry-based learning, gives a clear indication that much is yet to be done in order to provide classrooms not only access to on-line resources and tools, but to support teachers in engaging in advanced pedagogies instead of remaining transmitters of information (see Bracewell et al., 1998).

4.2.1 Benefits to expect are paralleling a number of features of on-going educational reforms:

- *Teachers' heightened sense of the relevance of longer learning time blocks.* The need for longer blocks of time to study one particular subject matter or integrated subject matters becomes more apparent.

- *Teachers' increased effort to develop interdisciplinary units and lessons.* The likelihood that learners be presented learning activities and projects that involve more than one subject matter at a time is enhanced.

- *Teachers' added support in organizing cooperative work groups, and multiple parallel classroom activities.* A few networked computers in the classroom become an incentive for rotating use and related learning activities.

- *Teachers' enhanced professional productivity.* In three of the largest initiatives conducted in the U.S.[17], teachers report using the Internet now slightly less for developing their technical skills and awareness, and more for getting information for instructional use (70-77%). Savings in paperwork and administration time as well as in accessing on-line educational services can be reallocated towards teaching and learning.

4.2.2 Provided that access is achieved, and that improvement of education remains the goal, while keeping costs in mind, the greatest effectiveness of the networked computer is most likely to be found in constructivist learning environments :

- *Students have access to extended sources of information and learn basic information skills.* The teacher and the textbook are no longer the sole sources of information in the classroom. Teachers and learners have more choice. While repeated access to large amounts of material at low cost is seen as a benefit at the postsecondary level (Massy and Zemsky, 1995), information finding and selecting on the Web are currently looked at as time consuming by K-12/13 teachers. When properly used, the Internet provides opportunities to develop students' abilities to select and organize information and to develop critical thinking skills. At the same time the teacher's time is more effectively spent in helping students search for information and make meaning of it, instead of simply transmitting information.

- *Students are presented with context-based or authentic learning activities, and new problem solving methods.* Contrary to common wisdom, the embodiment of activities in a real context becomes more feasible with the networked computer. Language learning becomes more of a reality when use is made of telecommunications such as e-mail, chats, or on-line discussion forums. Students have the opportunity to learn problem solving problems in real-world settings, or to simulate experiments that might otherwise be too time consuming, expensive, or dangerous.

- *Students engage in active learning.* The presence of computers in schools helps to support the teachers attempting to engage learners in active ways of learning – the very first learning principle put forward by the American Psychological Association in consultation with numerous educational groups in 1993. When students design and produce their own knowledge representations, they will find themselves engaged in a powerful learning experience. The networked computer acts as a catalyst for applying this principle in the classroom (Berge & Collins, 1998).

- *Students get involved in intra- and inter-classroom talk.* When one thinks of learning as a fundamentally social experience, he or she will notices that teacher-student and student-student communications extend when individual and collaborative inquiries are in progress – sometimes with community members and experts beyond the classroom. The information found on the networked computer must be sorted out, and its meaning needs to be negotiated with others. Learners may collaborate in interpreting data and information over the network, at times independently of time and space (Riel, 1995).

- *Students are given more attention.* Free of being the "one-and-only" source of information, the teacher can direct his or her attention to the needs and abilities of individual students and to learning teams. This benefit compares advantageously to the otherwise disproportionate amount of time previously spent answering questions posed by more advanced students. For instance, students' difficulties in understanding something become evident through the one-to-one electronic communications with the teacher.

- *Students develop project management, reasoning, and research skills.* Individual and collaborative project-oriented approaches allow students themselves to organize and conduct a learning project, taking, for instance, an in-depth look at a particular topic. They can locate resources and proceed to do what knowledge workers do, including scientists and scholars. Subject matter integration is

not only facilitated, but becomes necessary to the realization of a learning project. The SchoolNet's GrassRoots Program is an initiative found to be quite successful in helping meet the challenge of setting the conditions for the development of well-organized and structured projects, ones with high-emotional impact and high-educational value.

- *Students create learning artefacts.* Cognitive and socio-cognitive tools support school learners in constructing artefacts as they analyze a particular topic while creating a specific learning project (Bereiter, 1998). The computer is no longer a tutor or a repository of information: learners must intervene, organize and creatively represent information (text, picture, movie, audio, etc.).

Assessing how lifelong learning skills are acquired will take time. In the field of health we do accept, for instance, that cancer research is a long-term undertaking. The developing of the pedagogy of helping students acquire lifelong learning skills must also be perceived as a long-term undertaking just as is the case in the cancer research field. Meanwhile, research and measurement programs should be put in place where access is achieved, and focussed on the renewal of the structure of classroom activities and of the teaching-learning processes. After ten years of research in The Apple Classrooms of Tomorrow (ACOT), the research team was in a position to acknowledge that the whole classroom looks different (Sandholtz, Ringstaff, & Dwyer, 1997). In other words, the medium (ICT) and methods combine to interact with and influence how school learners process information (Kozma, 1991). This is a prerequisite to higher or more diversified quality learning outcomes.

4.3 Expected benefits at a later stage

Socio-constructivist researchers suggest that almost everything children learn depends on social interaction. They consider it very important that computers be capable of supporting person-to-person interaction and talk in and between classroom settings for learning purposes (see Wegerif & Scrimshaw, 1997). As a support for that interaction, there are Canadian developed learning systems that offer no pre-organized content, and are designed to be used as socio-cognitive tools (for communication and collaborative learning: e.g. First Class, CSILE/Knowledge Forum).

4.3.1 Let's underline what modern learning technologies can do to support teachers engaged in:

- *teaching for understanding.* When it comes to what subjects are to be learned, contemporary learning theory puts the emphasis on complex ideas – as they occur in authentic situations – because it is known today that school learners are capable of more advanced thinking than what is usually asked of them. In such circumstances, however, the evaluation of learning outcomes requires methods that measure understanding as opposed to methods that reflect the behavioristic theories of the past (Brown, 1994).

- *making a fundamental difference to students' achievement in academic subjects.* Students then tend to review and revise their own work more, and work on longer projects. Research demonstrates more persistence in solving problems and improved written communication when students use CSILE (Scardamalia and Bereiter, 1996). When the conditions are right (teacher basic technical training, constructivist pedagogy, team work among teachers, and administrative support as in the case of the CHILD project conducted in nine Florida elementary schools over a five-year period), the learning outcomes on standardized tests as well as the mastery of advanced topics are evidenced (see Dede, 1998; Kromhout & Butzin, 1992; Kulik, 1994).

- *improving students' higher-thinking skills.* The use of networked computers as cognitive tools, that is, with software designed to enhance the cognitive powers of learners while searching for information, writing, thinking, and solving problems (Jonassen & Reeves, 1996), helps them do more advanced academic work.

- *co-constructing with students knowledge of value to others (group productivity).* There should be collaborative work spaces for on-line knowledge building, that is, learning environments in which learners must co-construct knowledge and build their expertise in specific areas of inquiry. The

Web becomes a medium for learners to construct representations of their knowledge and negotiate the results and meanings of their inquiries. This collaborative-knowledge-building model deserves increasing attention and understanding (Brown, 1997; Hewitt & Scardamalia, 1998).

5.1.1Let's also underline what modern learning technologies will do to support school learners engaged in:

- *individual or collaborative learning.* Students will have increasing opportunities to interact with on-line teachers and peer learners. On the one hand, computer-supported independent learning will also increase as virtual learning environments develop, thus stretching the individual learner's capacity for autonomy and transfer of knowledge to authentic situations. On the other hand, computer-supported collaborative learning will call upon the individual's capacity to participate with others in inquiries, problem resolution, and a variety of learning activities and projects.

- *distributed learning.* Using a proper digital learning environment, networked computers create a collaborative learning space where learning may occur when students and/or teachers are not in the same room or accessing the Internet at the same time during the day or the week. It is a shift away from one-to-one/one-to-many communication patterns and toward many-to-many communication patterns, in which multiple individuals can simultaneously contribute to a classroom discourse (Tiessen and Ward, 1998).

- *lifelong learning.* The networked computer enables the implementation of a new learning paradigm, in which learning is viewed as an active process in which ideas and concepts are acquired and, manipulating symbols and data, put to test in action for deeper understanding. Students will get a solid foundation for lifelong learning work in a rapidly changing world.

- *deep understanding of advanced topics.* Students will reach a deep understanding of what they learn given that they are interacting with teachers (face-to-face and on-line) who are capable of advanced pedagogies. The level of mastery changes. Research shows that students are capable of mastering advanced topics at an age much earlier than is commonly thought.

- *developing a sense of advocacy.* As they progress in their expertise on certain topics, and get things done (learning *artefacts*), students have increasing face-to-face and on-line opportunities to let others know what they know. The Covis Project (Lento, O'Neill, & Gomez, 1998) also observed higher scores on standardized tests.

- *growing ties with human beings all over the world.* Students' use of the networked computer, the most appropriate multifaceted instrument to come of age for the development of communication between human beings, will provide multiple opportunities to encounter others from far-reaching socio-cultural contexts.

The above mentioned benefits are of great importance to a knowledge society. While the ones expected at an early stage require connectivity and basic technical skills, the ones expected at a later stage require a shift in the role of the teacher and the learner(s). Though most innovations in social systems require knowledge, individual accountability, group goals, structure and support, networking schools and classrooms presents a major challenge to the teaching profession. The successful preparation of workers and citizens for the knowledge age requires extensive teacher professional development.

5. Vision of a framework for the teaching profession using the networked computer

The new theory of learning that is now becoming widely accepted by cognitive and educational researchers – any paradigm shift takes time in a scientific community – is transforming the model of the human learner, including the child: school learners are to be viewed as active constructors, predisposed to learn certain things more readily than others (Brown, 1994; APA, 1993). (See also the Vision of learners in the 21st century, http://www.rescol.ca/general/visions/e/vision.html)

The expectations as regards the teacher's and the learner's roles are enhanced, and ICT can support this transformation process. The mission of professional teachers will continue to encompass intellectual, social, affective, physical, and moral dimensions. But the implementation of a new learning paradigm, enabled by ICT, calls for a critical inquiry into the so-called legitimate reasons, namely that of the social foundations, for keeping on with something called teacher-talk (vertical transmission of information followed by exams centered on rote knowledge). Though the decrease in the amount of frontal instruction and a move toward more project activities and independent learning associated with using ICT may have been obvious for some time (Kerr, 1991), these developments are dramatic changes in teachers' and learners' personal and social identities. Moreover, the shift to teaching for understanding calls for the higher-thinking and social skills of school learners (Dede, 1998).

But it is the teaching for understanding approach that can best help in facing the complex task of creating intellectually stimulating learning environments and democratic classrooms for tomorrow's citizens of Canada. It is also the appropriate way to face the challenge of meeting the nation's demand for knowledge workers (see the quantitative argument advocated by Drucker, 1997). For a well-coordinated and collaborative pedagogical effort to be effective, the networked computer becomes an essential instrument of the new pedagogy. Teachers need that tool to support this pedagogy and their own on-going learning.

Just-in-time learning is envisioned as an important feature in the professional development of tomorrow's teachers (see de la Mothe's emphasis on new forms of community and culture[18]). As knowledge workers themselves, teachers need therefore the flexibility, quality, collaborative practices and distributed cognition and leadership, now being found in knowledge workers.

5.1 Meeting provincial and international standards

Cuban, the author who provided the most comprehensive review of technology use in teaching in this century, captures in the following terms (1999) the embryonic level of use of computers by teachers in the classroom:

> Out of every 10 teachers in the US, fewer than two are serious users of computers and other information technologies in their classrooms (several times a week); three to four are occasional users (about once a month); and the rest – four to five teachers out of every 10 – never use the machines at all. When the type of classroom use is examined, we find that these powerful technologies end up being used most often for word processing and low-end applications. (...) Of those same 10 American teachers, about seven have computers at home and use them to prepare lessons, communicate with colleagues and friends search the Internet, and conduct personal business.

Cuban argues that there have been attempts in the past to change the teaching-learning process and that most teachers kept embracing a hybrid form of "teacher-centered progressivism," in which lectures and "teacher talk" continued to predominate. For the networked computer to become a socio-cognitive tool, classrooms and schools will need to become more learner-centred, and stress cooperative and collaborative learning. Collaboration of all educational partners is also key for channelling the forces at play in directions that will be effective and pedagogically sound. If their view is that Canada needs independent problem solvers, higher-order thinkers, teamworkers, etc., business and industry leaders also have an important role to play. They need to advocate for and support educational initiatives that realize these objectives and standards.[19]

It is up to each province to establish their own teaching competences. As this research review suggests, technology competencies that are closely related to advanced pedagogies are more beneficial. Time is often an issue in pre-service as well as in in-service teacher education. Thus, it is important that learning about technology be reduced to the essentials in order to invest into integrating technology into the curriculum and advanced teaching practices. The seven (7) technical abilities hereafter suggested make up ethnographic research results obtained from observing networked junior high classrooms at work, and cross-referenced with the International Standards for Technology in Education (ISTE), now adopted by the National Council for Accreditation of Teacher Education (NCATE) in the US :

- To use basic software tools to produce electronic documents (text editor, slide editor, html editor, spreadsheet, data base).
- To install and use peripherals (disk drive, compact disc player, printer, digitizer, electronic projector, speakers, video camera, compact disc engraver).
- To send email messages and attached files, to create a conference list and to obtain a new email address for a new user.
- To access different resources available on the network and to edit electronic documents (W3 or ftp)
- To access and respond to messages within conferences and edit new messages, perhaps to join a new conference.
- To manage students' documents, create electronic marks sheets or portfolios on the network.
- To authorize or restrict the access to files on the network, and to authorize access to specific lists on the server.

Next to training into the basic technical skills[20], the building of a critical mass of high-quality implementations of ICT in the life of classrooms becomes the task-at-hand.

5.2 Supporting at all levels teachers willing to engage in advanced practices

A remarkable research finding came out of a recent national study conducted in the United States (Becker et al., 1998) in which 4100 teachers from 1100 schools, were surveyed, and a [illegible]% response rate was obtained; it was found that the Internet-using teachers (5% of all teachers having their students access on-line resources and tools) were all constructivist teachers. These teachers set up more challenging learning objectives and tasks than traditional teachers, and were more interested in seeing that their teaching led to a deep understanding of content. The more schooling teachers have and the more they participate in professional development activities, the more their practice becomes constructivist. In contrast, their previous computer expertise does not seem to make much difference.

When a teacher looks for pedagogical benefits, he or she must be made aware that working with the networked computer as a tool is of a major importance, and that it is a tool whose use must be at all time subordinated to the user's needs. Modern learning technologies have undergone a metamorphosis stressed two Australian researchers, Toomey and Ketterer (1995), from teacher-proof instruments for providing instruction to valuable resources that young people can use on their own terms to help them learn. Teachers know that professional development must be essentially of their own individual making for true pedagogical benefits to unfold. Working in a school where a climate-for-change prevails is likely to influence the teacher's behavior accordingly.

While this paper recognizes that networked computers can support teachers engaged in their own school renewal or in on-line professional communities of interest, the reader must be aware, however, of Cuban's warning (1999): "what corporate cheerleaders, policymakers, and vendors who have far more access to the media [often] ignore are teachers' voices, the enduring workplace conditions within which teachers teach, inherent flaws in the technologies, and ever-changing advice of their own experts." Strong strategic partnerships aiming at improving learning are key.

School leaders as well as Faculties of Education leaders willing to make the necessary changes need grant programs in order to ensure equity of access, and to provide means to educators of educators to transform the content and process of their teaching. Incidentally, the U. S. Department of Education has just announced a $75-million-dollar program for the purpose of preparing tomorrow's teachers to use modern learning technologies – an equivalent program would request $7.5 million dollars in Canada.

Pilot projects[21] demonstrate that the sooner school teachers are equipped with a personal laptop, one that they can take anywhere, the sooner they will engage on producing digital educational materials for their classroom use and for the greater community of teachers and learners. To concentrate the effort of providing resources to the innovative teachers that are demonstrating on-going involvement in professional development activities is recommended. It might be the best group to target in order to get some fruitful results (see RITTI, a state-wide Rhode Island initiative in which 25% of state's teachers are provided a laptop).

Provincial ministries must spend funds on hardware and software, but they are also aware of the necessity of aligning forces on curriculum and teaching issues, and the SchoolNet website points to their groundbreaking efforts. As emphasized in a recent report[22], "what teachers actually need is in-depth, sustained assistance as they work to integrate computer use into the curriculum and confront the tension between traditional methods of instruction and new pedagogic methods that make extensive use of technology (p. 49)."

Vigorous ICT research and development, well-grounded and well-disseminated, is also essential to address the triple agenda facing school-based as well as university-based teachers, and understand how it is being achieved by: 1) learning the use of modern learning technologies (ICT), 2) learning to teach differently, and 3) learning to work collaboratively (at school and on-line).

5.3 Towards the collaborative culture for learning

The creative integration of ICT in the curriculum[23] is likely to bring significant changes in the way schools carry out their educational mission. The school culture is bound to open up and to become more collaborative for the teachers and learners to face the inherent changes called for by the wide acceptance of the networked computer. On-line discussions conducted on a small group, on a school basis or on a broader scale may greatly contribute to the development of realistic technology expectations (Calderon & Slavin, 1999; see Bélanger's paper, section 3.3). Locally well-established and inter-connected learning communities appear to provide most benefits: on-time access to resources, including best available practice on various subjects being studied, joint exploration of topics and issues, reflective analysis of educational situations, etc. Teacher learning communities that contribute to the intellectual life of the teacher outside the classroom (face-to-face and on-line discussions), and support his or her professional practice are key. The NetGeneration students are in the classroom. We want them to grow an identity as lifelong learners.

Whereas flexible learning delivery systems are expected to maintain the lead in education and provide individual workers/learners with the programs they need and when they need them, it becomes more and more evident that collaborative teachers' efforts and the shift to the collaborative classroom are likely to make a substantial difference in improving the condition of learning in Canada.

Conclusion

True enough, technology has automated many tasks but above all, it has challenged school learners and teachers to look at the world differently, and has presented them with additional opportunities for a more knowledgeable and creative performance. Their thoughtful and successful use of ICT in the classroom is of immense importance. Should the teachers get adequate access to the ICT and to professional development as to how to use it in their teaching, their pedagogical and technical abilities are bound to be enhanced by it.

Furthermore, in view of the fact that the location of the teacher's work is a factor which is now of much less importance, there are likely to be local people more involved in school life. This clearly constitutes a new avenue for the innovative teachers.

It must be pointed out that the new school learner, now well educated to get access to a worldwide available source of knowledge and equally well educated to make use of it, will surely feel less constrained when the time to look for a job arrives.

For all of us, the integration of multimedia network computers into education and training should be regarded as an opportunity and challenge to revitalize education for both teachers and students.

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[1] D. Tapscott presents (1998) the characteristics of the new culture of work (p. 211).

[2] The constructivist approach sees learning as an active process in which the learner is constructing a perspective or understanding through social interaction. Purely adding new data (rote knowledge) without structure or relationship to that which already exists is considered not enough. New information must connect with the learner's prior knowledge. The learner is active when building upon, extending or restructuring knowledge already acquired. Conceptual growth comes from the sharing of multiple perspectives, and deep learning occurs when mental models are revised.

[3] See STATS Canada's SITE Study to be released later this month for the latest data on the availability and use of computers in Canadian schools.

[4] P. Druckers argues (1997) that the only comparative advantage of the developed countries in the future will be in the supply of knowledge workers.

[5] See M. Fullan's works on educational change. See also the COMMITT Report, entitled *Courage & Care* (The Netherlands).

[6] E. M. Lento, K. O'Neill, & L. Gomez (1998) demonstrate best this point; see also T. Kieren (1998).

[7] For relevant presentations of modern learning theory: J. T. Bruer (1993), A. L. Brown (1994), L. Resnick (1998).

[8] See D. Macnab & G. Fitzsimmons (1998).

[9] Technology use is often at first a success story and later, a disappointment of sort, because, after all, it is the method of instruction and the media that count, not the media alone, see R. Clark, 1983, 1994; J. W. Schofield, 1995; Grégoire Inc., R. Bracewell, & T. Laferrière, 1996.

[10] The integration of ICT to the curriculum is the target of the SNAB's Research and Measurement Committee.

[11] See A. Breuleux, T. Laferrière, & R. Bracewell, 1998, and the University of Twente in The Netherlands, see Collis, 1996.

[12] The keen observer, however, detects the novelty effect, that is, the fact that a new learning method is becoming more exciting, while temporarily enjoying a significant increase in the learning performance. The Hawthorne effect must also be considered, that is, that any intervention tends to have positive effects merely because of the attention of the experimental team to the subjects' welfare.

[13] The SITE Study results will soon be available from STATS Canada, and provide most recent data.

[14] For a meta-analysis of research results in the use of the computer in the classroom that points to an average reduction of 34% of learning time, see Kulik, 1994; Khalili & Shashaani, 1994. In relation to writing, see Owston & Wideman, submitted. For reviews on the contribution of ICT on learning and teaching, see Grégoire et al., 1996; Bracewell et al., 1998.

[15] See Macnab, D., & Fitzsimmons, G. (1998).

[16] These initiatives are: The National School Network (NSN) organized by BBN in Cambridge, MA; the Rhode Island Teachers and Technology Initiative (RITTI), and the Union City On-line (UC) funded by the National Science Foundation.

[17] *Ibid.*

[18] de la Mothe (1999) points to the fact that "people and organizations are learning to cooperate as a competitive and survival strategy and in so doing they are using new information and communications technologies to network and reformulate the nature of their activity and to solve problems."

[19] Lewis (1999) provides a useful overlook at what is being done in other countries, namely in England, Scotland, Wales and the Republic of Ireland.

[20] In the U.S., teachers report using the Internet now slightly less for developing their technical skills and awareness and more for getting information for instructional use (70-77%).

[21] See the ASCD 1998 Yearbook, edited by C. Dede.

[22] See the *Report to the President on the use of technology to strengthen K-12 Education in the United States*, prepared by the President's Committee of Advisors on Science and Technology.

[23] *EdWeek* (1999). Building the digital curriculum, Technology counts'99, http://www.edweek.org/sreports/tc99/